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Summer (1980) Observations of Wolf-Bison Behavioural Interactions in Wood Buffalo National Park

Progess Report Number 4
May-September 1980

L.N. Carbyn, T. Trottier, S. Oosenbrug

Prepared For Parks Canada
and Boreal Institute
September 1981

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Prepared for Parks Canada and Boreal Institute

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March 19, 1982

Mr. W.D. Harper
Regional Director
Parks Canada
4th Floor, 391 York Ave.
Winnipeg, Manitoba
R3C 4B7

Mr. R. Jamison
Director, Boreal Institute
for Northern Studies
CW 401 Biol. Sciences
University of Alberta
Edmonton, Alberta
T6G 2E9

Gentlemen:

I am pleased to forward enclosed copies of the report "Summer (1980) observations of wolf/bison behavioural interactions in Wood Buffalo National Park" by Carbyn, Trottier and Oosenbrug. This is the fourth progress report on a major predator/prey study in Wood Buffalo National Park. Funding for this project was jointly through established CWS/Parks Canada agreement and through a Boreal Institute Grant (55-30075) to L.N. Carbyn. By obtaining outside funding the overall effectiveness of the research program was greatly enhanced. I would like to particularly draw your attention to the unique observations made on pages 37 - 52.

Yours sincerely

Gordon R. Kerr
Regional Director

Encl.

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We wish to thank the park staff for providing logistical support and for providing observers to continue observations while the principal field observers were on days off. A. Kennedy provided the necessary laboratory assistance and Rod Johnson of the firm KAO and Associates handled the computer processing of the data. E. Telfer and R. Leonard reviewed the manuscript. Financial support was provided by Parks Canada and a Boreal Institute Grant No. 55-30075 to L. Carbyn.

INTRODUCTION

This is the fourth progress report on wolf/bison studies in Wood Buffalo National Park. It includes the data collected from 10 May to 9 September, 1980. Main participants in the field work were T. Trottier and L. Carbyn. In order not to break continuity when the main observers were absent other observers participated from time to time. These were as follows:

P. Jalkotzy	10 - 13 July
D. Anions; S. Oosenbrug	14 - 18 July
M. Cobus; J. Johnson	18 - 21 July
B. Kozachenko	21 - 25 July
R. Lewis	25 - 28 July
G. Beaver; M.G. Bossenmaier	28 July - 1 August

V. Geist and P. Paquet visited the area and contributed to the program through discussion. In 1981 brief visits were made to the study area by L. Carbyn and R. Carson for purposes of gathering information for a diorama (Alberta Provincial Museum) and T. Trottier visited the area again 2-6 September.

Results presented in this progress report are largely descriptive and preliminary. The purpose is to present data collected in a specific period which can be incorporated into the final report.

The objectives of the 1980 summer studies at Lake One were to study antipredator strategies in bison, with particular reference to the strategy of protecting calves; to document hunting strategies of wolves, document bison use patterns of Lake One and to document some preliminary observations on bison behaviour. The latter information is useful in EAR Process and NRM Process of Parks Canada's resource management programs.

METHODS

Observations were carried out from a 2.5 m high observation tower (Fig. 1A). Equipment used included 7 x 56 Leitz binoculars, Bushnell scope, stopwatch, compass, and cassette tape recorder. Weather conditions (temperature, humidity, wind) were continuously monitored from a weather station located at the base of the tower. A Lambrecht anemometer and a thermohygrograph were mounted on a stand approximately 0.75 m from the ground.

Standard period of observations began at 0600 hours and lasted to 2000 hours, however, on numerous days observations began prior to 0600 hours and lasted past 2000 hours. Number of bison (Fig. 1B) in the Lake One prairie were recorded each day, and their movements recorded on maps divided into a .25 km^2 grid pattern (Fig. 1C). When herds overlapped, or no distinct herd pattern was discernable, grid locations were plotted at "centers" of herd locations. Data was computer coded and processed using a surface II graphics package in order to obtain 3 dimensional views (perspective diagrams) of the use of the Lake One prairie (see Fig. 3).

Classified counts were obtained in all cases where individuals could be identified as to age (young-of-year - calf, yearling, adult) and sex of adults.

Bison activities were categorized as follows:

- standing (chewing cud or resting)
- lying down (chewing cud or resting)
- grazing
- moving.

Figure 1. Scenes from Lake One, Wood Buffalo National Park.

Figure 1A. View of observation tower at Lake One in early mist rising over the prairie.

Figure 1B. Largest concentration of bison occurs in July, when the rut is in progress. Bulls are seen here tending cows.

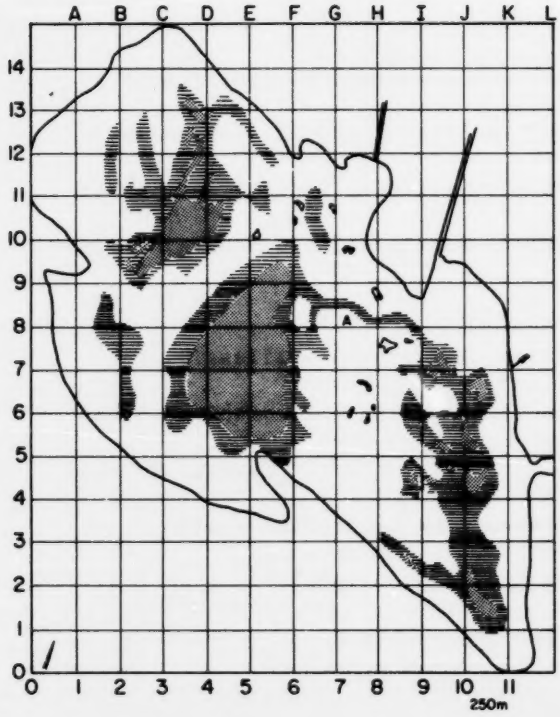

Figure 1C. Grid pattern used to describe bison use of Lake One prairie. A - location of the tower.

Figure 1D. Calves often were observed in groups called pods.

Additional behavioural activity patterns were noted and classified as fighting, drinking water, tree rubbing. Data on bison activity patterns were analyzed separately (Carbyn and Meleshko, in prep.).

Cow/calf interactions were studied in detail by recording events separately on special cards. Calf location in relation to the herd was categorized when first seen. Three categories were:

- at the periphery of the herd
- in a zone between edge and two-thirds to the central point
- within a central area (central one-third i.e. core area).

Similar criteria were used for moving herds. Stationary herds often became moving herds. Status of herds (moving or resting) were determined at 15 minute intervals.

Calf pod formations were examined as to constancy, numbers in the pod, location of pods in herds and numerical changes over a period of time. Criteria for pod formation was 5 m contacts over at least a 5 minute period.

Events relating to the birth of calves were recorded in as much detail as circumstances allowed. Defense strategies of bison to protect their calves were recorded by studying wolf/bison interactions.

Detailed descriptions of each wolf in the area were based on physical characteristics and behaviour. Notes were kept on group sizes taking part in hunting and travel forays. Hunting strategy was related to number of wolves, direction of approach to prey in relation to wind conditions, use of cover, and reaction to prey responses. Types of encounters were classified as wolves observing bison, approaching bison, trailing bison, testing bison, rush attack and observed physical contact.

Detailed combinations of encounters and prey responses were recorded by keeping a running description of the events and committing it to a tape recorder.

Flight responses of bison to potential human disturbances were investigated. This could have deleterious effects on bison by either increasing exposure of calves to wolf predation or changing traditional use patterns of the prairie area. Flight reactions include only those cases where bison fled upon discovering the human intruder. A reasonable effort was made to avoid being detected, by staying out of sight and at a distance considered beyond the ungulate's ability to recognize the disturbance. A distinction was made between Flight distance (distance between human intruder and the animal before taking to flight) and Flight reaction distance (the distance the animal ran to get away from the human intruder). Distances were estimated in paces. Bison responses to aircraft (fixed-wing and helicopter) were also noted.

RESULTS AND DISCUSSION

A. Bison - seasonal activity

Results of seasonal usage (May to September) of the bison in the Lake One area are summarized (Table 1). The graphic distribution of results are shown in Figures 2 and 3.

Bulls use the meadows throughout the summer, and observations in winter by wardens indicate small groups extending their use of the meadows year round. Bulls were more predictable and regular in their presence while cow-calf herds were more mobile and often left the main prairie. Cow herds without bulls were observed only briefly in mid-June.

Table 1. Summary of total number of bison observations in the Lake One prairie. These are cumulative values obtained from hourly counts and do not reflect actual bison numbers using the prairie area.

Time period Week	No. of bulls in bull only herds	No. of bull herds	Average bull herd size	No. of cows in herds with no mature bulls	No. of "cow herds"	No. of bulls & cows in mixed herds	Average mixed herd size	No. of mixed herds	No. of YOY	No. of YLY	No. of Unclassified	No. of cows
May 10 - 16	232	37	6.27	0	0	0	0	0	3	0	391	0
17 - 23	255	49	5.20	4	1	437	16.19	27	88	4	776	222
24 - 30	124	20	6.20	1	1	467	16.68	28	46	271	154	306
June												
31 - 6	106	32	3.31	22	3	828	55.20	15	135	320	2753	655
7 - 13	881	144	6.12	123	4	313	22.36	14	96	83	227	389
14 - 20	1100	219	5.02	11	2	1206	29.41	41	175	236	347	769
21 - 27	831	152	5.47	0	0	577	36.06	16	185	90	1096	322
July												
28 - 4	815	151	5.40	6	1	499	38.38	13	105	54	1187	368
5 - 11	1016	238	4.27	0	0	16	8.00	2	52	0	558	8
12 - 18	201	112	1.79	0	0	70	10.00	7	40	7	35	56
19 - 25	166	122	1.36	0	0	320	29.09	11	36	60	201	180
26 - 1	23	18	1.28	0	0	0	0	0	0	0	0	0
August												
2 - 8	14	11	1.27	0	0	0	0	0	0	0	0	0
9 - 15	81	71	1.14	0	0	116	6.82	17	0	0	0	0
16 - 22	80	63	1.27	9	4	586	32.56	18	256	37	1922	389
23 - 29	34	32	1.06	0	0	338	18.78	18	106	0	705	199
30 - 5	23	14	1.64	0	0	0	0	0	0	0	0	0
September												
6,7,8,9	25	16	1.56	0	0	21	7.00	3	6	3	0	9

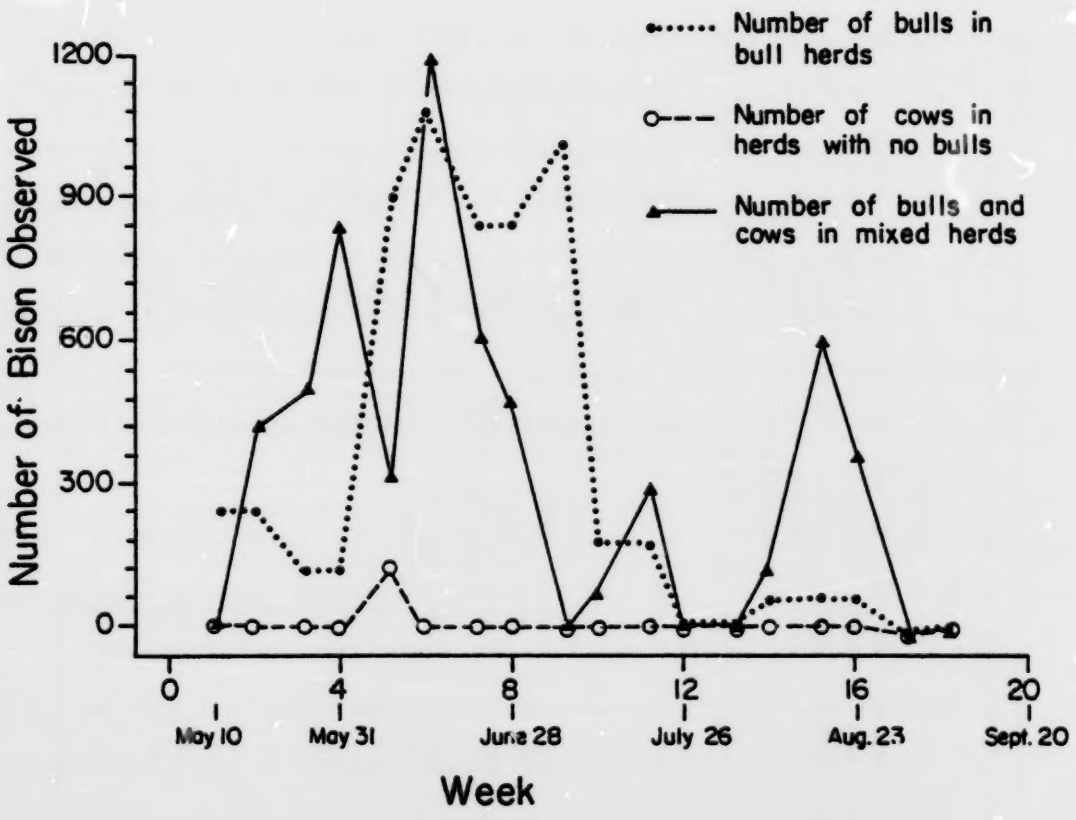

Figure 2. Seasonal use of Lake One meadows by bison. Figures refer to observation totals and not to total number of individual bison.

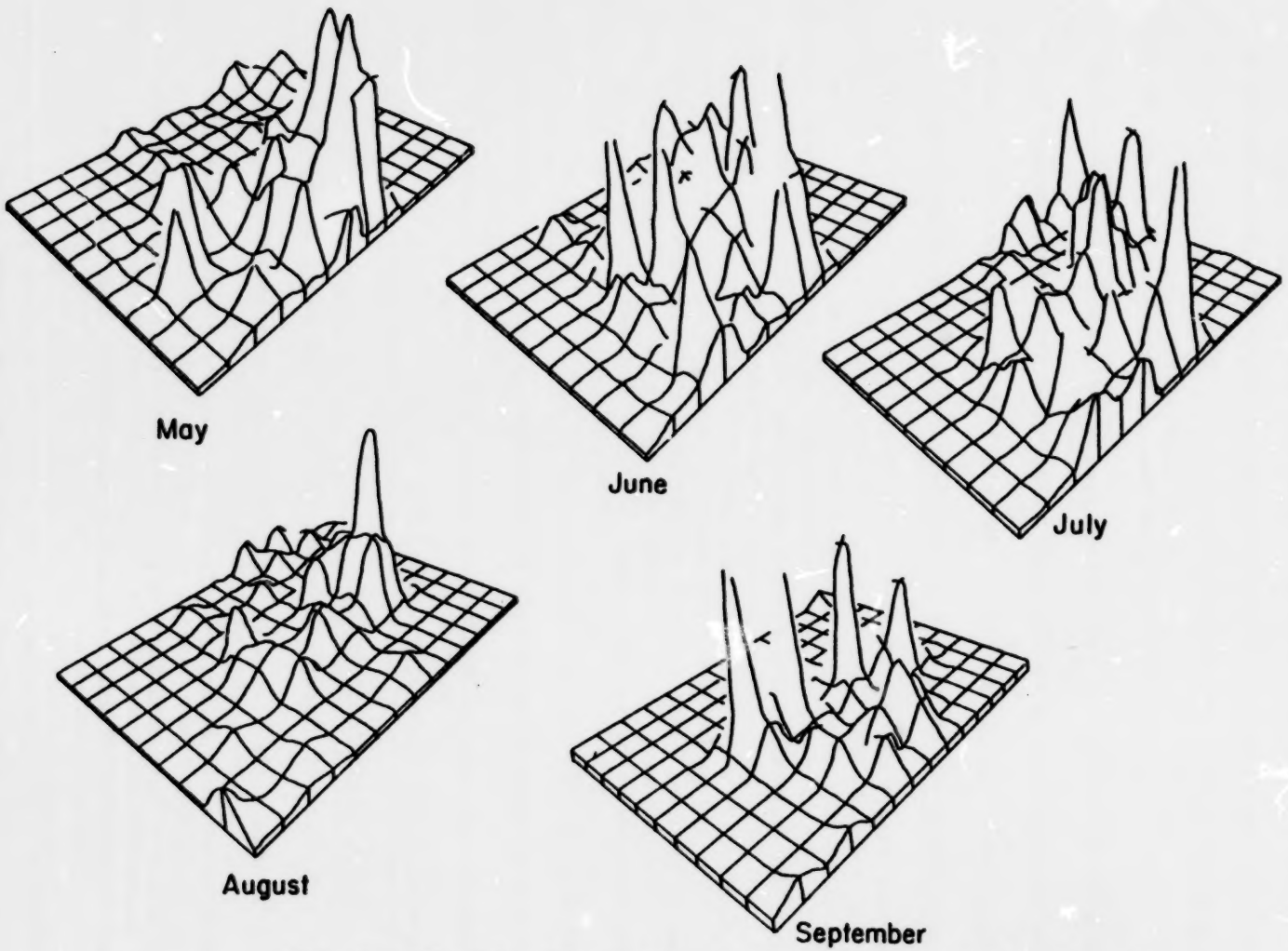

Fig. 3. Monthly Bison Usage of Lake One - 1980 indicating spacial utilization of the Prairie

Mixed herd usage of the meadows in 1980 were greatest from mid-May to mid-July. Mixed herds returned for a short period of time in the third week of August.

It is presumed that two major factors influence summer use of Lake One meadows. These are the rutting season and presence of water in the area and in the delta to the south. Prolonged dry periods probably reduce forage quality and could predictably influence range use. The rut begins around the third week of June but does not peak until later. Earliest report was for 20 June, 1978 (Oosenbrug, pers. comm.) although some signs of rutting were seen even earlier (May 20, 1980)[1].

One measure of the drought conditions in Lake One was the amount of water at a "watering hole" near the observation tower. In 1978, a year of greatest bison numbers at Lake One, the water was still present into late July, whereas by 9 June, 1980 the pond was without water and similarly in 1981 the pond had dried up by 2 June. Dry weather conditions appeared to trigger a grasshopper infestation. Nymphs were extremely numerous in May/June and adults were seen all summer in 1981, and such events could affect available forage.

B. Bison - classified counts

Results of classified counts (Table 2) are based on best counts, that is when a clear view at relatively close quarters was possible. A check on observer accuracy indicated that actual counts of yearlings in May and June were considered high, therefore, the May and June values were reduced by 20% when information was compared to criteria used by a

---

[1] A young bull pawed ground, urinated in wallows, showed aggresive movements towards other bulls.

Table 2. Classified bison counts, based on best counts only, summer 1980.

	Cows	Bulls	Yearlings	Calves	Calf/cow ratios	% Yearling
May	58	50	30	8	14/100	28%
June	352	182	94	66	19/100	18%
July	77	21	15	11	14/100	15%
August	84	60	7	28	33/100	5%
September	3	4	1	2	-	

second field worker. Accurate identification of yearlings can be a problem, because of their size when compared to older young of year or young two year olds. More experience gained subsequently reduced this problem. Overall May to June cow/calf ratio was 16.5 calves per 100 cows. Because the same cow/calf groups remained in the area and were repeatedly counted, these figures are not representative of the bison population as a whole.

C. Bison - human harassment

A total of 35 (see Appendix 1) flight reactions were observed where one or more bison became attentive and fled. In two instances the disturbances were by helicopters, and in one instance by a fixed-wing plane.

Adult bulls in small herds or singles were more common in the prairie area than mixed herds explaining the greater number (27 of 35) of flight reactions observed involving only bulls. Observations did reveal that bulls were less wary and not so quick to flee as were cow/calf herds. The average distance at which a bull or bulls detected a disturbance source was about 270 single paces.

The preliminary observations seem to indicate that hearing is probably a fairly important sense. These are subjective impressions gained by watching the bison closely and trying to anticipate responses to given conditions. A human moving along the prairie is visible at long distances, even to a bison who appear to have poor eyesight. When the wind is calm or light, bulls have been seen to react at the sound of a camera clicking 50 paces away, and other loud metallic sounds (climbing tower ladder) from 200-300 paces away. In 18 of 27 occurrences the observer was crosswind from bulls, twice downwind, and 7 times upwind. Only once when upwind of bulls, did they appear to react initially to human scent. Bulls may have reacted in part to human scent on two other occasions, though in both cases the observer was visible and only 250 paces upwind. Disturbances caused by helicopter (twice) and fixed-wing plane (once) resulted in all out full flight reactions. The sound of snapping twigs, rustling brush, and metallic clicks startled bulls on 5 occasions. In three cases the animals fled without seeing the source of disturbance. Twice bulls were startled enough to rise, but did not run until spotting the observer. In 10 out of 28 flight reactions by bulls did the stimuli of scent and sound appear to affect their behavior.

Sight appeared to be the primary stimulus in the remaining 18 occurrences. In fact, at least once two bulls failed to react to the loud sounds and scent of an observer 150 paces upwind, until he came into sight moving away from the bulls. Sounds strange to their environment, i.e. those made in the tower or with a camera and tripod, loud conversation, etc. invariably startled them when too close for the wind to drown out the noise.

It was noticed that after being on the prairie over a month, bulls in the area tended not to flee if the observer was a "respectable" distance away (i.e. ±400 paces) and was walking away from them. They still detected the human form, especially if it was moving and turned their heads and/or stood to watch. It may be that some bulls were growing accustomed to seeing a human often, thus were less likely to run. Also as the season progressed the bulls were entering the period of rut when their behavior became more aggressive. Twice bulls rose with tails up, backs arched, heads turned to the side watching the observer pass, but stood their ground. Once a bull in the bush at the edge of the prairie detected the observer at 100 paces. The bull gave a series of alarm "snorts" pawed the earth, followed the retreating human at a walk, wallowed and displayed behavior typical of the rut. After about 400 paces the bull stopped following.

Flight reaction distances of bulls varied from 10 to 1300 paces, but the average distance was 405 paces including both walking (48) and running (357). Bulls walked an average of 48 paces in retreat, and an average of 357 paces running away. They simply moved away slowly from the disturbance source (remaining on the prairie) 46% of the time, headed directly for cover 23% of the time and merely stood up once (4%). Bulls initially ran away from the disturbance, stopped to "back-check", then ran to cover (surrounding forest) on 15% of the occurrences. "Back-checking" refers to the habit of taking flight for a short distance, then stopping to look back at the source of danger. Back-checks occurred on 61% of the bull encounters, the animals then resumed normal activity, retreated further or disappeared completely in forest cover. In all

cases they changed their intent after "back-checking" to spot observer. A combination of behaviours with some members of a herd merely standing to watch and others moving away occurred twice (8%). Both times the observer lowered his profile and retreated. As described above one bull attacked rather than retreated from the observer. In this instance the observer surprised the bull from very close quarters in heavy cover.

Recovery times were recorded whenever bison remained in view. After bison had stopped their flight there was some variation in the time it took to resume normal activity. Estimates were broken down into categories: (0-1); (1-2); (3-5); (5-10); (20-30) minutes. Only those bison remaining on the prairie could be observed. Nineteen percent of the time that bulls ran or moved away, normal activity resumed within a one minute period; in 25% of occurrences this took place after (1-2 min.); in 25% of occurrences, after (3-5 min.); in 25% of occurrences, after (5-10 min.); in 6% of occurrences, after (20-30 min.). Thus bulls seldom took more than 5 minutes to resume their regular activities.

Six flight reactions involved mixed herds containing cows, calves, yearlings, and some bulls. One case involved a cow thought to have recently lost her calf to wolves. The average distance at which a mixed herd detected the source of disturbance was 230 paces, slightly less than for bulls. Animals in larger herds appeared to relax their senses somewhat (group security?). Cows, especially those with calves, appeared to be far more alert and reactive than bulls. The observer was upwind, partially obscured at 250 paces from a mixed herd that eventually fled. It appears that this herd probably responded after having caught the human scent. The bison at the time were being harassed by

wolves (then out of sight) which would have made them more alert. Cows initiated stampedes of mixed herds in two instances due to noises from the tower, and once as the result of a helicopter photographing bison. Thus they reacted to strange sounds, and in the latter case to excessive disturbance. In only two occurrences did it appear that cows of a mixed herd reacted by first seeing the observer. These preliminary observations seem to suggest that cows are more alert and may be relying less on sight to detect danger than is the case for bulls.

Flight reaction distance of mixed herds varied from 350 to 1200 paces and the average was about 742 paces their being considerably farther than for bulls. Mixed herds walked an average 100 paces in retreat, and ran an average of 642 paces.

In conclusion, the reactions of bison to human disturbances varied. Bull herds, pairs or singles usually reacted to a sighting at moderate distance by moving away from the disturbance. They were much less affected by man-made noises, especially when the source was out of sight. While it was difficult to determine how much bulls used the sense of smell, they rarely fled from someone out of sight but obviously upwind. Bulls were less reactive when compared to mixed herds, showing shorter flight distances both in situations where they ran and those where they walked away from the disturbance. S. Oosenbrug observed similar behavioural responses by bison to attacks of wolf packs in winter. Mixed herds had a lower flight distance (230 paces) and were more reactive to human intrusions. Mixed herds, especially the cow segment, were more easily frightened by noises than were bulls. While the latter remained down, continued grazing, or stared briefly, cows

would rise, watch intently in the direction of the sound, perhaps move away, and often stampede. The average flight reaction distance of the mixed herds exceeded that of bulls by about 285 paces.

These observations have some practical application in National Park interpretive programs. Observing bison in their natural environment is a great thrill for human visitors to the park. In many cases European tourists have come to Canada for the express purpose of seeing bison in Wood Buffalo National Park.

Observations on bison flight reactions to human disturbance at Lake One prairie indicate that humans encountering bison need to avoid detection, by staying under cover. Bulls frequenting the area appeared to grow accustomed to the repetitive presence of one or two observers and this may also be the case if small groups of visitors repeatedly use specific meadows with bull herds. Cow/calf herds on the other hand remain in a greater state of alarm, and closer contact should be avoided.

D. Bison - maternal behaviour

1. Parturition - nursing behaviour

Parturition may occur any month of the year. For example a trapper, F. Gibot reported seeing a newborn calf on 21 February, 1978 in the Sweetgrass area. In 1980, the first spring-born calf at Lake One was observed on 12 May. Detailed observations of the calf born 12 May revealed curious antagonistic behaviour by the cow towards the neonate. Nursing was interrupted by violent contortions of the cow. The calf was bunted and pushed to the ground and bulls was attracted to the unusual behavioural responses. The behaviour appeared to be that which has also been described for domestic cows with their first calf (V. Geist, pers. comm.).

Details regarding parturition of one calf was recorded on 3 June, 1980. The cow was part of a mixed herd of 91 bison. Three wolves nearby watched the herd at the time. Birth of the calf took place in the early morning between 0535-0730 hours. No unusual activities were noted within the herd when first spotted at 0535 hours. The calf was first seen at 0735 when it was still wet and the afterbirth protruded from the cow. It appeared that the cow did not leave the herd and that parturition took place at the edge of a prairie area adjacent to an island of bush. Upon being attacked by wolves the cow led the calf, still wobbly on its legs, to the safety of the herd center.

Appendix 2 lists the nursing sessions recorded for calves. Accurate times could not be obtained in some cases where, were the initial suckling period could not be recorded. In some cases it was not possible to observe whether the cow or the calf terminated the nursing bouts.

Table 3 summarizes the average suckling times over two week intervals. The greatest proportion of nursing took place during the morning (07-1200 hours) when calves are small and in the afternoon (13-1800 hours) when the calves were older. There was a general increase in length of suckling times as the summer progressed.

2. Pod formation

Criteria for calf formation was whether bison calves (two or more) remained in close proximity (within 5 meters of each other) for 15 minutes at a time. For data analysis, each month was divided into four week periods with the last two weeks being shorter or longer to adjust

Table 3. Summary of suckling times over two week intervals.

Period	# of observations	Average suckling times (minutes)	Time of day			
			0-6	7-1200	13-1800	19-1400
1 - 15 May	4	2.5 m	-	4	-	-
16 - 31 May	3	1.9 m	-	2	-	1
1 - 15 June	10[1]	3.7 m	-	3	9	2
16 - 30 June	9[2]	4.1 m	-	2	8	2
1 - 15 July	4[3]	3.8 m	-	3	3	-
Totals	30+9	$\bar{x}$=3.2 m	-	13	20	5

[1]Plus 4 observations with no times.
[2]Plus 3 observations with no times.
[3]Plus 2 observations with no times.

for uneven number of days in a month. Results are plotted in Figure 4 and were summarized in Appendix 3. In early May newborn calves stayed with the dams but as the calves grew older pod formation was noticeable from the third week of May to the 3rd week of July. Because of the virtual disappearance of herds in August little can be said of pod formation then, except that by the end of August when mixed herds had returned, pod formation was reduced but not absent. Weekly summaries are listed in Table 4.

In terms of monthly percentages (Fig. 4), the results indicate that in May 38% of the calf observations were within pods, 55% in June (peaked in that month) and then declined with the onset of the rut in July (34% of calf observations) and August (6% of calf observations).

Table 4. Weekly summary of calves seen in pods.

Month	Week One				Week Two				Week Three				Week Four			
	# Obser-vations	Total calf units	# diff. calves seen	% calves in pod total	# Obser-vations	Total calf units	# diff. calves seen	% calves in pod total	# Obser-vations	Total calf units	# diff. calves seen	% Calves in pod total	# Obser-vations	Total calf units	# diff. calves seen	% calves in pod total
May	N.A.				2	4	2	0%	20	80	4	80%	14	112	8	35%
June	30	128	15	68%	50	211	5	30%	123	411	4	55%	21	84	4	70%
July	34	109	7	9%	11	44	4	50%	6	18	3	44%		N.A.		
August	N.A.				N.A.				64	657	20	6%		N.A.		

Observations began during the first week of May. At this time the bison herds were moving north to summer calving grounds. Along the way and at the destination calves were being born. In the second week of May only 2 calves, both newborn, were seen, decreasing the probability of pod formation. Observations the third week of May were of a herd of 2 bison with 4 calves. None of these were believed to be newborn but rather were a week or more old. Calves at this age did not graze, were only moderately active and likely to rest in groups with parent cows grazing and resting around them. The low of 35% of calves in pods for the fourth week was based on only one observation of a very large herd (about 90 bison) that entered the prairie and stayed one day only. It appeared to consist of a collection of smaller mixed herds gathering along the route as the bison pushed north possibly as a result of changing weather conditions. It is believed that the larger number of calves (8), were less likely to form one large pod. Smaller pods were not infrequent and the proportion of pod to singles resulted in a depressed percentage of a pod formation, despite the fact that only one or two calves were believed to be newborn. One calf was at least a month old.

In the first week of June pod formation was high. At that time the calves were beyond the stage of exclusive parental attachment, and still too young to be independent. During this time wolf predation or harassment was not seen in the two herds observed. The value of 68%, lower than the earlier high of 80% is probably a result of the size of one herd, (100 bison with 9 calves). The chance of pod formation seems to decrease with ratio of calves to herd size.

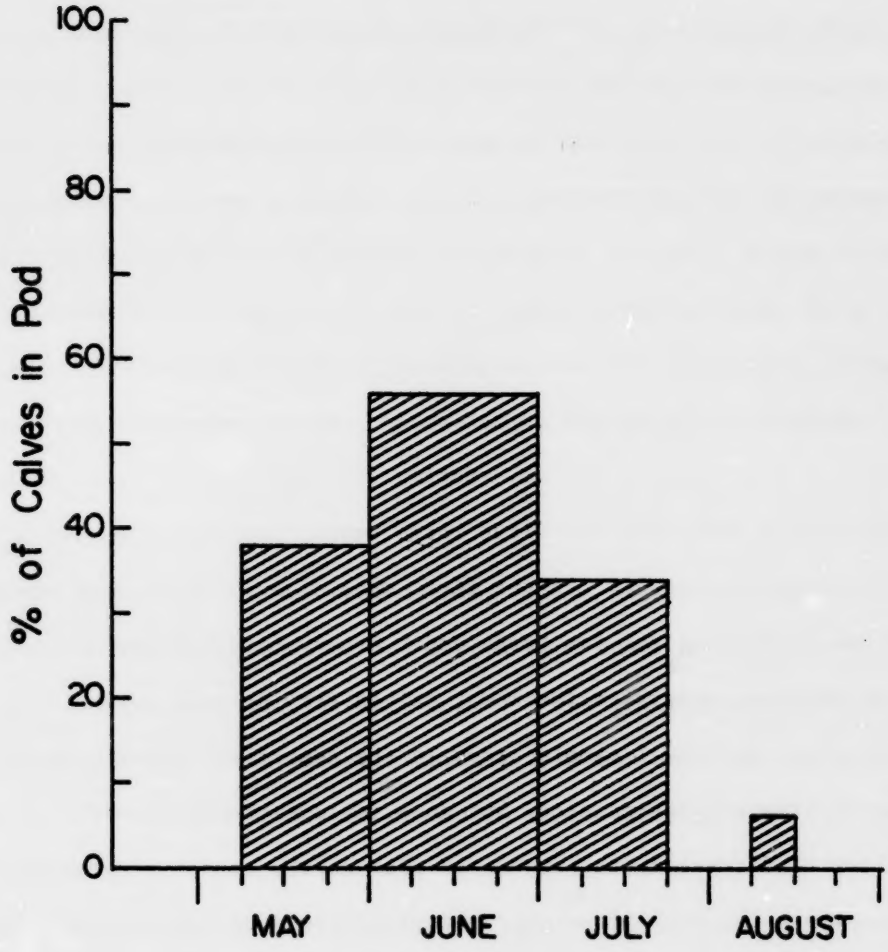

Figure 4. Monthly trends in calf pod formation (May through August 1980) at Lake One.

Low of 30% (second week of June) coincides with a period of intensive wolf predation on the single herd (30 bison) observed; 3 out of 6 calves in that herd were killed by wolves. Calves appeared to stay more closely with parent cows for protection in that herd. The herd was restless, on the move, and showing a defensive attitude, i.e. tight grouping and extreme wariness. Third week of June with a value of 55% calves in pod formation follows the long term average for June.

It appears that a number of factors affect pod formation. For example, during the hot days a general restlessness in the herd may perhaps have inhibited pod formation to some extend. Wolf predation may also be a contributing factor. During the last week of June, with a much lower sample size than the first three weeks, pod formation was up by 70% for no apparent reason. In the first week of July bulls were coming into rut and disrupting the two herds under observation. These mixed herds were restless, always on the move, calves staying with parent cows.

The very small sample sizes in the second and third weeks of July must be treated with caution, but does reflect the trend referred to earlier of decreasing occurrence of pods as the season progressed. Not until the third week of August were mixed herds of bison seen again. A large herd (120 bison) entered the prairie from the south, simultaneously with changing weather patterns. Most of the calves had acquired dark coats and all grazed to some extent, wandering more independently, but were still bonded to cows.

3. Calf position in herd structure

Position of calves were recorded as to edge, centre or mid sections of the herds. Distinctions were made for resting herds or

herds that were moving (Table 5), and between single (s) and groups (p) of calves.

The data indicate that in all cases i.e. for both single calves and for pods in stationary and moving herds the mid area was preferred. In moving herds the core was least frequented; for both single and pods and the results were statistically significant (P≤0.05). It therefore would appear that position of calves within herds is not a random occurrence and there could be an adaptive value which may function as an antipredator device. Obviously we have to review the literature on the subject on pod formation in other bovids and evaluate the data more critically.

E. Wolves - Lake One pack

During the denning and post denning period 8 adults (7 in the pack plus one of unknown status) and 6 pups were under observation at Lake One. Sex ratio of adults was 3 males, 3 females and 2 of unknown sex. The densite was located approximately 1 km northwest of the prairie (Fig. 5). The den was abandoned around 26 June. This den was not used in 1978 or 1979. A check of the study area in the first week of September 1981, revealed that none of the 1978, 1979 or 1980 nursery dens was used. Total pack size in 1981 was 12 (4 pups).

To facilitate behavioural observation in 1980, each adult wolf was named and described in as much detail as possible. Descriptions were as follows:

W.G. White-grey appeared to be physically the largest wolf in the pack. It was a male with light, buff colouration. Black guard hair extended over the back, shoulders and withers with another black streak

Table 5. Position of calves in relation to herds.

Month	Stationary herds						Moving herds					
	Edge		Mid		Centre		Edge		Mid		Centre	
	Single	Pod	Single	Pod	Single	Pod	Single	Pod	Single	Pod	Single	Pod
May	41	2	40	10	9	2	30		23		6	1
June	37	22	70	59	45	23	65	23	135	33	10	4
July	7	2	55	10	-	-	-	-	14	2	7	2
August	28		84	8	40	3	66	8	63	2	52	2
Total	113	26	249	87	94	28	161	31	235	37	75	9

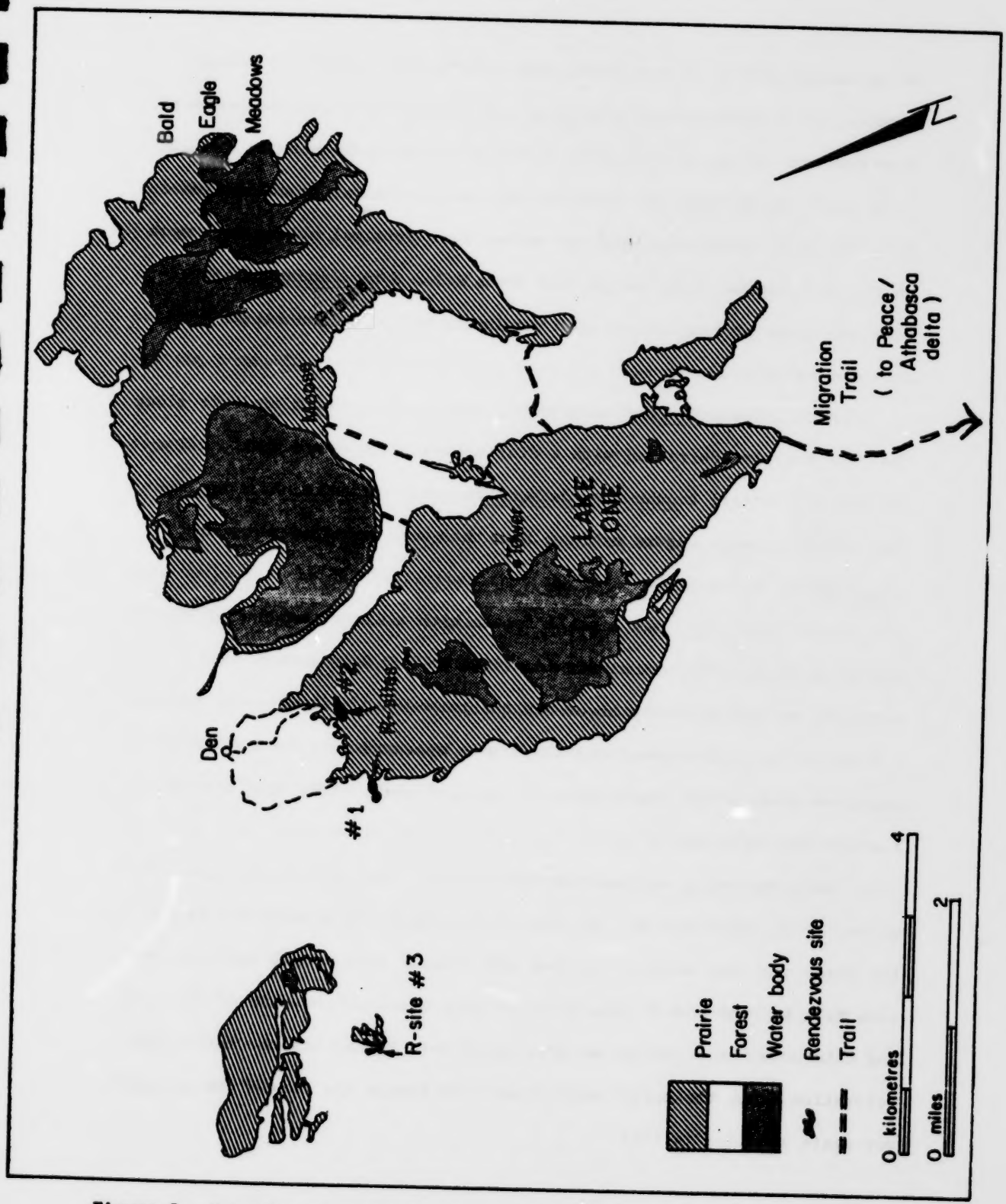

Figure 5. Location of maternity den and rendezvous sites of the Lake One pack.

being conspicuous along the front legs. Ears were reddish in colour. Despite the loss of winter hair, W.G. retained a full bodied appearance when compared to the other wolves. This wolf was again seen in 1981.

S.M. Silver-Mane was another large male, similar in coloration to W.G. but unlike W.G. this wolf was marked by a vertical oblong dark spot on the left flank. S.M. was smaller than W.G., more slender in appearance and appeared long-legged upon losing winter fur. The animal survived to 1981.

N.D.G. New dark-grey was another large male. Light tan buff along the face sharply contrasted with a distinctive black "face mask". From the tip of the tail to the shoulders, this wolf was marked by a distinctive black stripe. Again by late June this wolf appeared rangy and long-legged.

B.T. Black-tail was a small female with a large head and wide appearing snout. She was almost identical to N.D.G in colour and markings, except that only about one quarter of her tail near the tip had a black stripe. Throughout the summer she appeared very "skinny" almost emaciated with a very characteristic "whispy" tail. This wolf was the dominant (alpha) female.

D.G. Dark-grey was another female and resembled B.T. in coloration. This wolf, however, was darker in overall appearance and lacked the sharp contrast between the face and sides. This animal was smaller than B.T. and had a more pointed snout with black on the side of the nose and chin area. Another characteristic of this animal was the marked red coloration along the upper legs, flanks and behind the ears. The animal was again recorded in 1981.

L.W. Lame wolf, sex unknown, was identified by its severe limp. Its left front leg hung loosely at the joint and was thrown forward with each step. The physical disability did not appear to affect the wolf's relative dominant position in the hierarchy as described later. The wolf was grey in colour, showing no outstanding coat patterns.

C.W. Collared-wolf was a small light grey female without outstanding coloration. The animal had previously been captured and wearing a non-functional radio collar at the time of observation.

Ch-W Charcoal-wolf a small, light grey wolf of unknown sex was seen only once during the summer.

F. Wolves - pack dynamics, behavioural observations

Seven wolves were the most seen together at one time. These were seen on 10 May, 1980. Thereafter that the pack was observed to hunt and travel in "subpacks" or as singles.

Wolves were seen on 98 different occasions. White-grey was the dominant male (Table 6), however, a curious relationship was noticed when New-dark-grey was present. Under such circumstances the latter appeared to dominate more often (Tables 6 and 7), which leads us to conclude that conclude that there were two very dominant males in the pack. Many detailed descriptions of behavioural interactions were recorded, but only a few are outlined below to illustrate the curious dominance relationships between two "alpha" like males.

1. Observations of wolf leadership were noticed during attacks on bison (Table 7). The first prolonged physical attack on a bison calf happened on May 28. In a series of encounters throughout the day

Table 6. Alpha male leadership of wolves in wolf-wolf encounters.

Wolf	Sex	WG "Leaderships" over	# times	NDG-"Leadership" over	# times
White Grey (W.G)	M	NDG, DG, BT, SM + 5 pups	1	WG, DG, BT, SM, LW	1
New Dark Grey(NDG)	M	DG, BT, L.W	1	WG	1
Dark Grey (DG)	F	DG,	1	WG, BT, SM & DG.	1
Balck Tail (BT)	F	BT,	1		
Silver Mane (SM)	M	SM, Ch-W	1		
Lame Wolf (LW)	?	SM	1		
Collared Wolf (CW)	?				
Charcoal Wolf (Ch-W)	?				
Totals			6		3

Table 7. Leadership of wolves in wolf/bison encounters involving 2 or more wolves.

Wolf	Sex	WG Leader	#	NDG Leader	#	D.G Leader	#	BT Leader	#
White Grey (W.G)	M	NDG, DG, BT, SM	3	WG, DG, BT, SM	1				
New Dark Grey(NDG)	M	*DG, BT, SM	20	WG, DG, , SM	1	WG, BT, SM	3	WG, DG, SM	1
Dark Grey (DG	F	DG, , SM	2						
Black Tail (BT)	F	BT, SM	2						
Silver Mane (SM)	M	DG	1						
		BT	1						
		SM	5	WG, SM	2				
Totals			31		4				1
Wolves present		WG present 42 times		NDG present 7		DG present	29	BT present	27
Wolves leader		34/42		4/7		3/29		1/27	
% leader of times seen.		81%		57%		10%		4%	

*Main hunting unit.

White-grey usually led the pursuit over Silver-mane, Black-tail and Dark-grey when the chance of a kill was high, the other wolves responded less to White-grey, and more to the fleeing calf. This prominence, however, became more and more evident later in the day when the wolves were tiring. White-grey led attacks then almost exclusively, and was the last to retreat and on at least three occasions carried out the attacks alone, the others being out of range or holding back. Dark-grey twice tested the herd alone, while the other wolves watched and rested. Silver-mane was the follower that day, waiting for White-grey to make the first moves. The rare times that Silver-mane assumed a lead was when the wolves pursued bison and White-grey dropped back momentarily. Occasions when White-grey gave up on an attack the others followed. Black-tail frequently lagged behind the other wolves, joining them only during actual attacks or when resting in the bush. She seemed reluctant to press during attacks on bison. It appeared that this wolf was the alpha female, nursing pups.

2. Observations on 3 June (field notes) indicated the prominence of New-dark-grey as dominant male. This animal appeared to be less closely bonded to the other wolves, however, he was part of the pack and occupied a dominant role. This wolf, together with collared wolf, were first seen separate from the main pack on 3 June. Silver-mane was closely bonded to White-grey and this relationship was observed on many occasions. However, when New-dark-grey appeared he usually assumed the dominent role. Field notes, collected on 17 June, are relevant to the conclusion that two dominant males were within the pack. "New-dark-grey appeared on the prairie, leaving the den area, followed 250 meters behind, by White-grey.

As they travelled SSE, the leader stopped four times to raised-leg urinate, raised his tail and scratched, and at each location White-grey also stopped and did the same. While in sight and moving (25 min) New-dark-grey always took the lead." The second indication that this essentially lone male (at least less closely bonded to the pack) was at least equal in status to White-grey was strengthened two days later on June 19 when early in the morning five wolves (Lame-wolf, Dark-grey and Black-tail, White-grey and Silver-mane), watched a mixed herd of bison 300 paces to the south. "White-grey got up deliberately and advanced toward the herd, walking slowly with his head low." Dark-grey and Black-tail followed closely while Lame-wolf moved up quickly from the rear with silver-mane behind (him). Then a sixth wolf (New-dark-grey) howled once from the bush north of them. Black-tail and Dark-grey reversed direction and trotted toward the now visible New-dark-grey, Silver-mane and White-grey also retreated from the herd as well, but did not go to meet the sixth wolf. Lame-wolf and Black- tail trotted quickly up to New-dark-grey, their tails low and wagging, reaching out to lick his muzzle. The former stopped his advance, tail straight and wagging, head up and ears forward. New-dark-grey trotted off toward the others with Black-tail and Lame-wolf following closely. New-dark-grey then continued SE and was followed shortly by White-grey, then Black-tail and Silver-mane. As they crossed the prairie White-grey managed to take the lead for about 50 meters then dropped back again behind New-dark-grey. White-grey, Silver-mane, and Dark-grey responded to New-dark-grey's call but did not approach him submissively as did Black-tail and Lame-wolf.

It was noteworthy that Silver-mane followed White-grey away from the herd and that White-grey appeared to take the initiative at first, but was then thwarted by New-dark-grey. It is easy to get lost in anthropomorphic interpretations. However, it looked very much as if White-grey led an attack on the bison which was then "called-off" by New-dark-grey. There was no question that the pack immediately changed its activity and that all other wolves, were subordinate to New-dark-grey.

On 21 June 1980, five wolves (W.G, N.D.G., B.T., S.M and D.G.) harassed a mixed bison herd for 4 hours. Initially New-dark-grey led in the attacks. White-grey clearly followed at first but as the attack persisted became more aggressive. All other wolves, including New-dark-grey became disinterested as the day wore on and left. White-grey persisted in the attacks. On another occasion (August 23, 1980), New-dark-grey again led an attack on a mixed herd of bison. The next day (August 24, 1980), seven adult wolves attacked a mixed herd with three calves, White-grey led the attack and ran past trailing bulls. New-dark-grey followed White-grey. Silver-mane and an unidentified wolf followed but were attacked by flanking bulls, causing the wolves to alter their course. Three more wolves (including Black-tail the alpha female) followed. White-grey terminated the pursuit as a result of attacks by bison. Further pursuits that day were unsuccessful.

An observation on feeding sequences, provided further information on dominance. Three wolves (White-grey, Dark-grey and Black-tail) were feeding an a bison calf killed early on June 15, 1980. When first spotted at 1020 hours, White-grey was resting 20 paces from the kill.

The blood stained face indicated that he had already fed. Dark-grey and Black-tail were feeding together for 10 minutes. Both left to drink water. White-grey (dominant male) and Black-tail (dominant female) both returned to the kill, with only Black-tail feeding. White-grey then displaced Black-tail and fed for 30 minutes. During this sequence the dominant male did not feed with other wolves at the kill at the same time and that he fed longer then the beta male and alpha female. These observations are at odds with winter observations.

On another occasion (August 24, 1980) six adults and five pups were observed at a kill. Initially these wolves were kept from consuming the calf by a bull which through slow, deliberate and threatening stances kept the wolves at bay. White-grey remained watching while the bull disappeared and did not immediately approach the kill. Action was partly obscured but it appeared that initially only 2 pups fed on the carcass which was then followed by one unidentified adult. White-grey fed next, causing wolves present to vacate the carcass. White-grey was briefly joined by one adult and one pup, both of whom he tolerated. After about 5 minutes White-grey left, thus resulted in a "free for all" descent on the carcass by other wolves. These observations indicated that the alpha wolf inhibited general utilization of the carcass by other wolves, but some were allowed to feed before the food consumption by the alpha male. Pups were more readily tolerated then adults.

G. Wolves - pup activities at rendezvous sites

Six pups were observed briefly on June 10, 1980 at their nursery den. Upon spotting two human observers about 20 meters away the pups fled to the entrance, hesitated briefly, (Fig. 6) then entered. There was no

Figure 6. Wolf pups, judged to be about 8 weeks old, observed at the north end of Lake One meadows on June 10, 1980.

evidence of the presence of adults at the den. Again on 19 and 26 June pups were in the den when checked and adults were not in attendance. It is believed that the first rendezvous-site, located about 1 km from the den was established between 19-26 June and that both the rendezvous-site and den were used simultaneously at that time.

The first rendezvous-site was located in a low lying area of three small meadows which were separated from each other and from the main Lake One prairie by fringes of willow bush and black spruce. Aspen covered sandridges, grading into black-spruce-feathermoss communities in upland sites bordered the are to the north. Bison trails ran through the sand ridge areas. The rendezvous-site was heavily used, numerous trails connected activity sites, beds and "playdens". Thirty-seven pup scat and 7 adult scats were collected at site 1.

The second rendezvous-site was first occupied between 11-15 July. It came into existence by a gradual extension of movements from the first site. Possibly pups extended their movements from the first site as they followed adults or met them upon their returns from hunting forays, thus gradually using new areas which in time became the focal point of their activities. The second rendezvous site was located on the slope of a low sandy ridge in close proximity to the 1978 nursery den.

Rendezvous-site number two contained remains of a young bison bull (known to have died of undetermined causes in early spring), beaver bones and feathers of waterfowl. Total of 104 pup and 21 adult scats were collected from site 2. Between 22 July and 7 August the pack extended its movements 4.5 km northwest to a series of small grassy clearings, low lying wet areas, covered by willow bush along low lying depressions which

formed the focal point of the third rendezvous site. At this location a bull bison carcass, believed to have died in early May, 1980 was utilized. In mid-July the cow-calf bison herds had largely disappeared from Lake One meadows, and wolves probably extended their hunting forays over wider areas. A total of 73 pup and 42 adult scat samples were collected from site 3.

Adult scat at rendezvous-sites were usually collected at the periphery of play areas or along trails leading to them. Pup scats were typically found along a network of trails, bedsites and playdens in the rendezvous-sites.

The large bison carcass, with skull, vertebral column and ribs still attached, was extensively chewed on by pups and probably also the adults. Pelvic girdle was in place, however, all four legs were disarticulated. Scapulae were found at the rendezvous site. Scattered remains of hide, hair and rumen lay close to the carcass.

After 23 August the pack had left their traditional rendezvous-sites to roam more widely. On 23 August the pack was observed at a kill. On 25 August and 6 September two pups were seen alone and their continual "mournful howls" and their erratic searching movements suggested that they were abandoned. The ultimate fate of these two animals could not be determined, but it is quite possible that they succumbed. Based on the observation in the two years at least 7 wolves were lost from one year to the next.

A single coyote was observed at rendezvous site 3 on 25, August. On another occasion (30 May) a coyote was spotted at Lake One, but not in association with wolves. Only once (6 July) was a black bear seen near a wolf, however, no interactions were observed.

H. Predator/prey interactions - predation on calves

Detailed sequences of attacks were recorded. Because of the unique opportunity to observe these interactions, a description of the events are listed below.

May 28, 1980. - Wolves had been testing several small bull herds and one cow with a young calf (5-10 days old) for 3 days, before major skirmishes on 28 May. During the three day period it was obvious that bulls, particularly yearling bulls, were effective in protecting the calf. Remarkably persistent attacks culminated on 28 May.

A small herd (15 bulls, 1 cow and young calf) were resting at 0620 when 4 wolves were spotted lying about 200 paces from the bison. Wolves made no effort to conceal themselves. At 0720 bison got up and started to graze. Bulls began to disperse and the cow led her calf away from the wolves. When the cow and calf began to run the wolves followed, circling the bulls. Five bulls had separated themselves from the main herd and the cow led her calf to this group of bulls. The four wolves, now separated again pressed the attack. One wolf attacked the calf and the cow wheeled around and charged with head low and tail raised. The other three wolves passed the cow and chased the calf. In the meantime the five bulls ran back and surrounded the calf while attacking the wolves. Wolves pranced around constantly dodging the attacks by the bulls. This interaction lasted only seconds, the wolves retreated; the cow and calf, surrounded by bulls, in a tight group walked to higher ground. As it moved on the herd spread out, bulls butting one another (displacement activity?) A lone bull, separated from the herd, charged Dark-grey and

White-grey causing the former to retreat, the latter to move well to the side. Silver-mane met Dark-grey and both veered southeast to rejoin White-grey. Black-tail lagged behind. Again the herd bunched up surrounding cow and calf, most watching the wolves which were then 200 meters to the northeast. All four wolves laid down in a lowland sedge area, but with heads up. At 0835 Dark-grey arose and trotted southwest closer to the bison, which were by then spread out and grazing. The second attack began when the cow and calf trotted south away from the herd. The herd ignored the cow until the four wolves flashed by in pursuit. White-grey caught up first, was turned aside by the charging cow and veered around to catch up to his mates and the running calf. Then wolves grabbed the calf and pulled it down. It struggled free and ran off in a half circle. The cow met it coming back, along with several bulls. Individuals charged the circling wolves with tails raised. The cow stood with head turned aside and the calf pressed against her flank.

Dark-grey and White-grey trotted 150 meters east of the tight group. Silver-mane and Black-tail "patrolled" the opposite side of the herd. Shortly the cow raised her tail and trotted off leading the calf and the bulls south. White-grey and Dark-grey were quickly forced back when the bulls charged. White-grey veered and soon passed these stragglers. The other wolves followed, all descending on the fleeing pair who were seperated from the herd. The cow turned to meet them as her calf once again fled, this time running in a tight circle back towards the advancing bulls. The bulls crowded in, advancing towards the wolves.

Fifteen minutes after this attempt 3 bulls, the cow and calf were standing 100 meters south of the main herd. Bulls were grazing and lying down chewing their cud. The wolves rested, 100 meters north of the herd. The situation remained thus until 0910, at that stage 3 hours had elapsed since the first attacks. Dark-grey was first to rise and cautiously moved by the flanking group of bulls. White-grey and Silver-mane followed, but when all three were between the bulls, the group with the cow and calf began walking south. The wolves trotted behind, then retreated when the bulls turned on them. Seven other bulls were coming from the north, and successfully chased the wolves aside and thrwarted their efforts. At 0915 the cow, calf and 5 bulls had walked further southwest close to cover. The remaining bulls lagged behind grazing in widely scattered groups. Dark-grey arose and trotted south, then east until well past the cow-calf group. White-grey and Silver-mane walked between trailing bulls. Black-tail sat and watched from the north. At first it appeared the wolves wanted to prevent the cow and calf from entering the bush, but it then appeared as if the wolves were trying to stampede the small herd and cause them to scatter. When the cow and calf broke away heading towards the bush, Dark-grey joined White-grey and Silver-mane who swung around and ran parallel to the bush, effectively cutting off the quarry. The cow and calf turned back to the slower bulls. By now Black-tail had advanced toward the action almost hesitantly. Eventually she wandered over to the bush and out of sight. When the group containing the cow-calf bolted a second time several bulls entered the bush and disappeared. The cow, however, veered southeast then turned abruptly along the side of a sand Ridge where she and 7 to 11

bulls kept the wolves at bay for two hours. During this time the cow stood near her calf and grazed for a while, the bulls also grazed, some disappearing into the bush. All four wolves wandered back and forth along the ridge, eventually lying down at 20 to 50 paces from the shielded calf. The cow descended the ridge, heading north at a fast walk, however, the calf lingered behind with a group of bulls until she was about 150 paces away. It then descended the ridge and was detected by White-grey lying 100 paces from the scene. The cow ran back and escorted her calf up the ridge as White-grey and the other three wolves came from the south side of the ridge. The wolves were attacked by several young bulls at the top of the ridge.

By 0940 all four wolves retreated to a spruce and willow swamp southwest of the sandy ridge. White-grey remained in the open close to the base of the ridge. For the third time the cow headed north off the ridge and across the prairie, apparently leading her calf away from the wolves. Four hundred meters out she stopped to look back and waited as her calf reluctantly descended the ridge to follow. When it was 50 paces out White-grey came around the ridge beginning pursuits for the fourth attack. From a halting gait the wolf levelled out into a fast lope while the calf quickly reached its mother and both ran rapidly north, but after 600 paces she was forced to turn and defend it. The calf swung around and was knocked down by White-grey who had just dodged the cow. The calf scrambled to its feet and fled with a burst of speed leaving White-grey behind to face the cow. But he ran after the calf as it ran back toward the ridge and an approaching young bull. The cow cut the wolf off and struck him with her forefeet. The wolf rolled over once, came to his

feet and ran quickly, past the young bull, and almost caught the calf as it descended the ridge. At the same time three other wolves came over the ridge and three bulls on top surrounded the calf. The cow and young bull returned in seconds to help drive off the excited wolves.

At 1000 hours the bison descended the ridge moving slowly southeast. White-grey, Silver-mane and Black-tail retreated to young aspen bordering the southern prairie edge. Then Dark-grey trotted off behind the herd, rushed the calf, then veered to avoid the charging bulls. The wolf then joined her pack mates. The bulls were quick to resume normal activity, but the cow and calf remained very alert. At 1030 hours the cow headed east, but the calf lagged behind with three young bulls. The wolves stood at the edge of the bush then proceeded out into the prairie. Both calf and a young bull trailed after the cow and when the calf drew ahead of the bull, White-grey began a halting gait, his three mates close behind. The wolves were about 300 paces behind, when both cow and bull spun around to defend the calf. Wolves "flowed" around them and avoided the charges. The cow ran northeast followed by her calf. Three more bulls approached from the sand ridge. The wolves passed them and overtook the prey. White-grey grabbed the calf (fifth time) at the back of its left flank only to be chased off by two bulls and the cow. A skirmish occurred, bulls charging, wolves dodging and rushing the calf with the cow at its side. Two wolves downed the calf again (sixth time), but it squirmed out and took off running. Three wolves pulled the calf down again (seventh time), but again the adult bison chased them off. Four very excited wolves were prancing around, circling, and darting in looking for an opening as bulls and cows

shielded the calf. White-grey persisted, finally grabbing the calf again (eight time), but was chased off by the cow. The downed calf rose slowly this time and stood weakly. It was wounded in several places. The wolves persisted as the cow and calf trotted northeast, four young and two mature bulls following behind. One young bull escorted the cow. The wolves were apparently tiring cantered along behind with White-grey leading. When the herd gathered and stopped near an aspen bluff, the wolves returned into tall grass and rested. The cow moved off again with the calf and two bulls following behind. The wolves sprang up and gave chase again. When they overtook the foursome, two bulls wheeled to charge, but the wolves by-passed them and soon overtook the cow and calf. The cow turned on them but they veered around her and caught the still-running calf. Two wolves grabbed it (ninth time) by the hind legs, the calf kicked itself free while running. Three bulls then rushed in to protect it. White-grey charged the group with tail swinging in an arc over his back, but was forced to spring back to safety. The pack circled around the bison looking for an opening. White-grey was most persistent. When the remainder of the bulls caught up the cow started in a very tight formation walking back in a northeasterly direction.

At 1105 the cow and calf ran off to the east once more, bulls trotting 20 meters behind. White-grey and Dark-grey sprinted after them, the former pulling ahead with Silver-mane and Black-tail trailing but the cow turned and ran back to the bulls who shielded the calf. Then she bolted, heading northwest with her calf. The wolves rushed in, not soon enough as four young bulls closed around the twosome. The cow ran off again, her calf and one bull trailing. The wolves appeared to be tiring

(panting hard), but some gave chase with Black-tail trailing. A stand off resulted with cow and bull protecting the calf until the bull charged, allowing Dark-grey, White-grey to lunge at the calf. The calf wheeled around the cow who charged at the wolves, the calf ran in a circle and returned to the other three bulls, while this occurred White-grey and Silver-mane grabbed the calf by the rump (tenth time) taking it down. The cow and bulls chased them off, the calf scrambled to its feet and ran back to the sand-ridge followed by two young bulls and the cow. Once more the pack nearly caught up to the calf but the bulls were surprisingly fast and quick on the defense.

Five hours had elapsed since the chase began, still the wolves persisted and still the calf survived the ordeal. It was, however, injured and bleeding from various cuts. At 1110 the wolves persisted for another 10 minutes. As the herd walked quickly along, White-grey, Silver-mane and Dark-grey ran up alongside darting in and out of the herd harassing them, trying to get at the calf which seemed doomed at this point. The herd turned back towards aspen cover, walking briskly with a young bull out front trotting. The wolves appeared exhausted and were panting. White-grey led, the other wolves following at a slower pace. The cow waited for the other bulls to join her, then continued on. The wolves dropped well back of the herd as though tiring. Only White-grey accelerated his movements when the cow and calf outran the herd, but at this stage even this wolf was unable to overtake the bison. Chases back and forth continued. The calf walked stiffly, limping on at least one leg; yet it could still run and seemed to have the stamina to do so when needed. The herd spent an hour grazing then drinking water. They led the calf away and was followed first by the young, then by older bulls.

By 1330 hours all were down and remained so until 1630 hours. Finally the target cow and calf got up. She waited as her calf slowly hobbled up to her. Close examination of the calf revealed wounds on the upper left front leg where it meets the chest, on the blood-smeared forehead, with conspicuous wounds on the lower hind legs. The upper right hind leg was noticeably swollen. There was no sign of any profuse bleeding and the rain soaked prairie probably kept blood washed off its legs. Fifteen minutes later, White-grey appeared from the north. The wolf trotted almost in a straight line towards the bison. The other three wolves also appeared, White-grey passed the older bulls, who seemed to ignore the wolf, then was discovered by the cow-calf herd. The bison drew together and walked to higher ground. The herd stood huddled, tails raised watching White-grey swing northeast, away from them to rejoin the other pack members. They were already 600 meters away when for some unknown reason the nervous cow bolted and led her calf away from the protection of the herd. White-grey looked back and saw them, quickly started back. He broke into a fast lope travelling a straight line through hummocky water-soaked lowland responding to a sudden dash by the alert cow southwest of where several bulls were grazing The wolf overtook and passed the cow, but the calf out front reached one bull who swung around defiantly. The calf fled around to the protective side of the bull. White-grey, unable to stop and perhaps intending to ambush the calf appeared to leap over the bull's rump. Cow and bull with back arched and tails raised shielded the calf from the prancing, excited wolf. The wolves subsequently left and reappeared at 1730 hours. At that time the cow, calf and one mature bull grazed and stood only 50 paces away from Dark-grey. The subordinate female wolf kept up a brisk,

steady pace as if ignoring the bison, then suddenly rushed the calf. The bull spotted her and charged. The cow reached its calf and Dark-grey was forced to retreat. At 1800 hours, White-grey entered the prairie exactly where Dark-grey had trotted northwest using the same technique as Dark-grey. Despite his white appearance, the wolf was very close to the calf before the bull appeared to notice him. The cow rushed up to face Whitegrey, but the wolf out-manoeuvered her and leaped after the calf. It ran a tight circle trying to shake the predator and return to safety, but was hit on the right shoulder (eleventh attack) before cow and bull chased the wolf away. He circled the huddled trio, tail wagging as he watched briefly from 10 paces away before continuing westward abandoning the chase. This was the last encounter observed, and the ultimate fate of the calf is unknown.

The cow, calf and bulls were observed frequently for the next two days. The calf, very stiff at first, appeared to quickly recover from the ordeal, and was seen "frolicking" after a 24 hour period.

Strategy of the wolves was to lie in waiting, then when the herd was moving they tried to isolate the calf from the adults. The calf survived because of its incredible speed, its very agile movements when downed and by the quick defensive responses of the bulls. Particularly effective were the younger bulls.

During the major portion of the summer repeated observations of wolf/bison encounters involved a mixed herd of 28 to 32 bison, initially containing six calves. June 6, 1980. - The above herd (at the time consisting of 21 cows, 4 yearlings and 3 unclassified animals) were observed from 1440 hours to 1700 hours. The herd was seen resting at the

edge of a bush and were under constant surveillance by 4 wolves. Bison intermittenly stood up, were seen briefly grazing or calves nursing. There were no major movements until 1600 hours. Wolves did not relax their vigilance throughout. At 2130 this herd was seen, again moving restlessly. Calves, whether resting or moving, always appeared to favour the mid-area of the herd. Wolves followed the moving herd in an uncoordinated fashion.

June 12, 1980. - At 0635 the above herd moved along the edge of Lake One prairie while Dark-grey was trailing the herd at 50 to 250 paces. The wolf veered around the herd and entered bush while the bison began to graze. Cows and calves moved in the central portion of the herd. Bison moved into cover and were followed by 2 wolves. At 0730 the herd stampeded out of the bush, several rear adults turning as if facing wolves which were not seen. Then the herd returned into the bush along a migration trail. At least two wolves followed and, although not witnessed, (dense vegetation), a calf was attacked and killed. Chase in the bush was for about 300 paces. A cow was seen at 1330 hours, moving about quickly suggesting stress. Vocalization included grunting, interrupted by loud "snorts". The cow charged White-grey while he was feeding on the calf. The cow spotted the human observer nearby and with raised tail slightly back, advanced slowly. The observer quickly retreated. The cow returned to her calf two more times that day (1920 and 2200 hours). It was noticed that the cow received gashes along the upper left flank and that her tail was missing. Portions of the tail were found at the killsite. Virtually nothing remained of the calf carcass within a 24 hour period. Left were small tufts of hair, small

portions of both scapula, small portion of pelvis and portion of lower jaw.

Another calf within the same herd, seen limping on 13 June, was walking slowly and had trouble getting up to it feet. On June 14 only 4 calves were seen, therefore, two were missing of which one was unaccounted for. Observations of the herd, curious behaviour of one cow (identical to that observed in the cow that had lost her calf on June 12) and the persistent movements of White-grey to a specific area also frequented by the cow was strong evidence that the limping calf had been killed and consumed by wolves.

June 15, 1980. - Details of an attack on the same herd were not obtained, however, at 1020 hours two wolves (Dark-grey and Black-tail) were seen feeding on a bison calf while White-grey rested nearby. Inspection of the kill an hour later revealed that mortal wounds were inflicted to the right shoulder, exposing the lungs. Flesh from the left femur was all that had been consumed. Rigor mortis had not set in and it was judged that the calf had been chased and killed in an open prairie. Trampled grass for 20 paces indicated the trail of attack. Examination of the site one day later revealed that all portions were either eaten or had been dragged away, as the only evidence of the kill was trampled and blood stained grass.

August 24, 1980. - A bison calf was killed and consumed (details have been described earlier).

J. Predator/prey interactions - analysis of attacks

A total of 166 wolf/bison encounters were observed (Table 8) during the summer 1980. Various degrees of interactions were observed and an attempt were made to analyse these as follows:

Table 8. Number and types of wolf/bison encounters observed from 9 May to 9 September 1980.

Type of Activity	Single Wolf		Pack (2 plus) wolves		Totals (single and packs)	
	#	% type activity	#	% type activity	#	% type activity
Watch only	12	23	4	3	16	10
Watch plus follow up	14	27	30	26	44	27
Trailing only (+ watch)	7	14	11	10	18	11
Trailing plus follow up	3	6	22	19	25	15
Testing only (+watch; +trailing)	10	20	20	17	30	18
Test plus follow up	0	0	3	3	3	2
Rush only (+ watch; + trailing + testing)	4	8	13	11	17	10
Rush plus follow up; physical contact	1	2	9	8	10	6
Spontaneous Physical contact (without testing)	0	0	3	3	3	2
Totals	51	100	115	100	166	100

a) Watch only (passive) a wolf or wolves observed bison and may have avoided or retreated from them, but did not trail or test.

b) Watch plus follow up - a wolf or wolves observed bison, then trailed only or tested and/or rushed and/or made physical contact with them.

c) Trailing only (+ watch - passive) a wolf or wolves followed a moving herd of bison (and may or may not have been observing them), but did not test or rush or make contact.

d) Trailing plus follow up - a wolf or wolves followed a moving herd of bison (and may or may not have been observing them), then tested and/or rushed and/or made physical contact.

e) Trailing only (+ watch; + trailing) - a wolf or wolves approached bison in full view close enough to get a reaction; an attempt to cause a bison or herd to take flight or scatter and expose vulnerable members, i.e. calves. The predator (may or may not have been observing and/or trailing, but) did not rush and make physical contact.

f) Testing plus follow up - (active) a wolf or wolves tested bison (and may or may not have been observing and/or trailing), then proceeded to rush possibly also making physical contact.

g) Rush only (+ watch; + trailing; + testing - (active) a wolf or wolves ran after or towards a target bison, i.e. calf, with intent to kill, (and may or may not have been observing, and or trailing, and or testing), but did not make physical contact.

h) Rush plus follow up (physical contact) - (active) a wolf or wolves ran after or towards a target bison, usually a calf, with intent to kill, (and may or may not have been observing, and or trailing, and or testing), but did make physical contact with the intended victim.

i) Spontaneous physical contact (without testing) - (active) a wolf or wolves rushed and made physical contact with a target bison, without perliminary testing, trailing or watching, as during a series of attacks where the target has previously been identified.

1. Types of Encounters

There were twice as many encounters by pack wolves than by single animals (Table 8). As expected single wolves merely "watched bison more often then packs. On only 32% of the occasions did single wolves follow up with "pursuit" as opposed to 68% for packs. Again pack animals more often (88% of observations) followed up "trailing" with "pursuits", as opposed to 12% of the time for single wolves. Pack animals also were more likely (67% of the time) to test animals as opposed to 33% of the single observations. Sequence of activities leading up to and including a "rush", but not an "attack" included 24% of observations involving single animals but 76% of these involving packs. Wolves were observed making physical contact with the bison on 10 different occasions of which only once (10% of observations) a single wolf was involved. "Spontaneous" physical attacks, those incidents preceded only by a rush, where exclusive to pack situations.

In considering the above it is important to keep in mind the following sequences. A physical contact cannot occur without a prior "rush"; however, a rush need not be preceded by testing or other activities. The same applies to testing, and trailing. Therefore sometimes a wolf or wolves "observing", or "trailing" might go straight to a "rush". A few observations indicated that a few activities required no preliminaries before a rush, i.e. wolves repeatedly, but unsuccessfully rushed and contacted a calf in one or two minute periods. This explains why, in the single wolf column there were no recorded "test", plus "follow up" cases, yet there were cases of a wolf rushing its prey.

Also "trailing" only occurred when a herd was on the move, as some instances the sequence could jump from "watching" to "testing", begin at "testing", or even at "rushing". Thus of the five activity types performed by a single wolf 23%, include "watch only" while 27% include "watch plus follow up". In 14% of cases a single wolf did no more than "trail" bison and 6% describe still further action. "Testing only" with or without prior activities occurred in high proportion -20%, while "rushes without physical contact" occurred only on 8% of the observations, making "contact" 2%.

The data suggest that single wolves rarely were motivated to carry the attack to its logical extreme i.e. killing the prey. On the other hand, packs when encountering bison seldom stopped at watching only (3% of the observations). While packs stopped at trailing bison on 10% of the observations, they went further (trailing plus follow-up) 19% of the time.

Testing by packs occured 17% of the times observed but was followed through on only 3% of the observations. Packs rushed bison on 11% of the observations and made contact on 8% of these occasions.

In summary the following conclusions can be reached:

a) In the sequence of activities the preliminaries of a hunt, i.e. watch, trail and test are exercised much more often than actual attack phases, i.e. rush and contact, for both single and pack components.

b) Passive encounters prevailed in situations involving a single wolf. For example single wolves went only as far as trailing prey (passive) on 14% of the times, followed up with testing (20%) of the time (active and attacked on 10% of the occasions (active).

c) Active encounters prevailed more often in cases were packs were involved.

2. Predator targets

Age and sex are important considerations in selection of target animals by predators. An analysis of the predator/prey interactions was carried out to see if wolves randomly approached bison or selectively chose specific target group (Table 9).

From this information it can be seem that wolves definitely selected for herds with calves and indeed the results were highly significant ($P<.001$). This selection process was most pronounced for packs. Single wolves more often than packs would interact with bull only herds (34% vs. 5% of such encounters); suggesting that interaction of single wolves with bison represented a more random pattern whereas packs deliberately formed hunting groups seeking out vulnerable prey.

Table 9. Wolf encounters with different types of bison herds.

	Total herds		Single wolf		Packs (2 plus wolves)		Total	
	#	%	#	% of encounters	#	% of encounters	#	% of encounters
Mixed herds without calves	46	3%	3	9%	2	4%	5	6%
Mixed herds with calves	184	10%	19	54%	51	91%	70	77%
Bulls only	1501	86%	12	34%	3	5%	15	16%
Cows only	16	1%	1	3%	0	0	1	1%

3. Wind/cover relationship in hunting patterns

The direction of approaches by wolves in relation to wind direction while encountering bison were recorded (Table 10).

There appeared to be no definite pattern that indicated a deliberate directional approach to bison. Both single and pack wolves were seen more often approaching bison across the direction of wind then either downwind (expected if wind direction is important) or upwind. A similar analysis was carried out taking cover[1] into consideration as well. (Table 11).

Again there appears to be no consistent pattern as the number of "crosswind" observations exceed the "downwind" locations that would be expected if wolves used the wind direction to their advantage.

K. Predator/prey interactions - predation results

1. Kills

Details of kills involving calves have already been discussed. In addition to the 4 calves, two adult bulls were found dead, both of which were believed to have died (killed by wolves or otherwise) in late winter. Wolves were observed feeding on a freshly-killed mature beaver carcass on 8 June, and on 10 July a single wolf (most likely BT) was seen "pouncing" on a prey item in tall grass which turned out to be an adult red-tailed hawk (P. Jalkotzy, pers. comm.).

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[1]Defined as any object, vegetation or geographical feature providing a visual break, which is of potential benefit to the predator in approaching the prey.

Table 10. Types of approaches by wolves when stalking prey as related to wind conditions.

	Single wolf		Pack (2 plus wolves)		Total (single + pack)	
Wind condition	#	%	#	%	#	% direction
Wolves upwind from prey	6	50	6	50	12	13
Wolves downwind from prey	12	67	6	33	18	20
Wolves crosswind from prey	17	28	44	72	61	67
Total	33	38	56	62	91	100

Table 11. Types of approaches by wolves when stalking bison as related to wind direction and cover.

	Single wolf				Pack (2 plus wolves)				Total (Single and pack)			
	Under cover		Open		Under cover		Open		Under cover		Open	
Wind conditions	#	%	#	%	#	%	#	%	#	%	#	%
Wolves upwind from prey	2	33	4	14	1	50	5	9	3	38	2	11
Wolves downwind from prey	3	50	9	31	0	-	6	11	3	38	15	18
Wolves crosswind from prey	1	17	16	55	1	50	43	80	2	24	59	71
Total encounters	6	-	29	-	2	-	54	-	8	-	83	-
% encounters	17	-	83	-	4	-	96	-	9	-	91	-

2. Scat analysis

A total of 850 scat samples were collected during the summer 1980. Breakdown is as follows:

Densite	Pups	Adults	Unclassified
Prairie area	288	155	73
Rendezvous site # 1	37	7	
Trails between #1 and #2	4	28	
Rendezvous site # 2	104	21	
Trails between #1 and #3	8	10	
Rendezvous site # 3	73	42	
Total	514	263	73

A contract technician identified remains in 428 samples. The results are listed in Tables 12 and 13.

Muskrat and beaver hair are difficult to distinguish microscopically, (Kennedy and Carbyn in prep.). Together these species constituted the most important food sources, accounting for about 63% of the summer diet of wolves.

If waterfowl are included, then about 71% of the food, based on data obtained in scat analysis, is derived from marshy or aquatic environments. Snowshoe hare provided about 19% of the food source. Bison on the other hand accounted for only about 3% of the food items in scat samples.

Table 12. Results of analysis of scat collected in summer 1980 in Wood Buffalo National Park.

				% occurrence of food items		
Food item	Pups	Adults	Combined	Pups	Adults	Combined
Muskrat	168	53	221	55.1	41.7	51.2
Snowshoe hare	49	31	80	16.1	24.4	18.5
Beaver	46	4	50	15.1	3.15	11.6
Waterfowl	27	8	35	8.9	6.3	8.1
Unidentified	4	13	17	1.3	10.2	3.9
Bison	2	10	12	.7	7.9	2.8
Microtine	2	1	3	.7	.8	.7
Squirrel	2	2	4	.7	1.6	.9
U.I. feathers	2	1	3	.7	.8	.7
Porcupine	2	-	2	.7	-	.5
Vegetation	1	-	1	.7	-	.5
Grouse feathers	-	4	4	-	3.15	.9
Total	305	123	428	-	-	-

Table 13. Relative occurrence of food items. (Value of 1 single item; .5 each for two items and .4, .3, 3 for three items.)

				% occurrence of food items		
Food item	Pups	Adults	Combined	Pups	Adults	Combined
Muskrat	157.5	51	208.5	55.3	44.7	52.3
Snowshoe hare	48.5	26.5	75	17	23.3	18.8
Beaver	46	4	50	16.1	3.5	12.5
Waterfowl	17.5	4	21.5	6.1	3.5	5.4
Unidentified	4	13	17	1.4	11.4	4.3
Bison	2	10	12	.7	8.8	3
Microtine	2	1	3	.7	.9	.8
Squirrel	2	2	4	.7	1.8	1
U.I. feathers	1	.5	1.5	.3	.4	.4
Porcupine	2	-	2	.7	-	.5
Vegetation	.5	-	.5	.2	-	.13
Grouse feathers	-	2	2	-	1.8	.5
Total	283	114	396	-	-	-

Appendix 1. List of flight observations of bison in the presence of human intrusions.

Obs.	Date	Disturbance type	Flight distance (paces)	Source (wind)			Wind Direction	Numbers			Direction & distance moved (paces)		Flight cover for			Bison back check	Time to resume normal activity (grazing) min
				Up	Down	Cross		Male adults only	Mixed herds	Female adults only	walk	run	cover	stood	prairie		
1	May 9	Helicopter	500	-	-	-		9	-	-	-	100 SE	-	-	X	-	-
2	May 13	man	500	-	-	-	SE	16	-	-	-	400 E	X	-	-	-	-
3	May 13	man	250	X	-	-	S	9	-	-	-	250	-	-	-	-	-
4	May 13	man	300	-	-	-	S	5	-	-	-	250	-	-	-	-	-
5	May 14	man	150	-	-	-	Calm	-	17	-	-	800 E	X	-	-	-	-
6	May 14	man	200	X	-	-	E	2	-	-	-	500 NW*	X	-	X	X	-
7	May 18	man	200	-	-	-	SSW	1	-	-	-	500 NE	X	-	-	X	1-2
8	May 19	man	400	-	X	-	SW	6	-	-	-	550 S	-	-	X	X	3-5
9	May 20	man	200	-	-	X	SW	2	-	-	10 SW	-	X	-	-	-	0-1
10	May 21	man	100	-	-	X	SSW	10	-	-	200 SE	-	-	-	X	X	0-1
11	May 22	man	300	-	-	X	NE	3	-	-	100 W	450 S	-	-	X	X	3-5
12	May 24	man	350	-	-	X	NE	7	-	-		50 SW*	-	-	X	-	-
									-	-	-	500 NE	X	-	-	X	-
13	May 26	man	300	-	X	-	NE	3	-	-	-	350 N	X	-	-	X	5
14	May 30	man	400	-	X	-	N	-	40	-	150 W	200 W	-	-	X	X	3-5
15	June 2	man	100	-	-	X	E	-	150	-	200 N	300 NE	-	-	-	-	-
												700 E	-	-	X	X	5-10

Appendix 1. Continued.

Obs.	Date	Disturbance type	Flight distance (paces)	Source (wind)			Wind Direction	Numbers			Direction & Distance moved (paces)		Flight cover for			Bison back check	Time to resume normal activity (grazing) min
				Up	Down	Cross		Male aduts only	Mixed herds	Female adults only	walk	run	cover	stood	prairie		
16	June 3	Helicopter	100 ft. above	–	–	–	N	–	69	–	–	1000 E	–	–	X	–	20-3
17	June 7	Fixed-wing plane	200	–	–	X	SW	14	–	–	–	50 E	–	–	X	X	1-2
18	June 8	man	300	–	–	X	SW	1	–	–	–	–	–	X	–	–	1-2
19	June 9	man	200	X	–	–	S	6	–	–	150 S	400 S	–	–	X	–	0-1
20	June 9	man	300	–	–	X	SW	6	–	–	(1)100 E	(3)500 W*	–	–	X	–	–
												(2)150 W	X	–	–	–	–
21	June 10	man	250	X	–	–	NW	4	–	–	30 E	1000 E	–	–	X	X	5-10
22	June 12	man	250	X	–	–	NW	–	35	–	50 E	700 E	X	–	X	X	–
23	June 13	man	150	–	–	X	E	7	–	–	–	200 N	X	–	X	X	–
24	June 14	man	500	–	–	X	S	–	–	1	100 S	250 S	Toward	Toward	Toward	X	?
25	June 21	man	200	–	–	X	SW	3	–	–	–	1000 E	–	–	X	X	5-10
26	June 22	man	200	–	–	X	NW	–	30	–	200 N	150 NW	–	–	X	X	3-5
27	June 24	man	200	–	–	X	SE	1	–	–	–	200 NE	–	–	X	X	3-5

Appendix 1. Continued.

Obs.	Date	Disturbance type	Flight distance (paces)	Source: Up (wind)	Source: Down (wind)	Source: Cross (wind)	Wind Direction	Numbers: Male adults only	Numbers: Mixed herds	Numbers: Female adults only	Direction & Distance moved (paces): walk	Direction & Distance moved (paces): run	Flight cover for: cover	Flight cover for: stood	Flight cover for: prairie	Bison back check	Time to resume normal activity (grazing) min
28	July 5	man	300	-	-	X	NW	7	-	-	-	(5)350 N	-	(2)	X	X	1-2
29	July 5	man	400	-	-	X	SW	1	-	-	-	400 S	X	-	-	-	-
30	July 6	man	250	-	-	X	NW	24	-	-	-	500 NW	X	-	-	X	-
31	July 7	man	200	-	-	X	E	3	-	-	-	(1)200 E	-	(3)	X	-	3-5
32	Aug 9	man	200	X	-	-	SSE	1	-	-	250 NE	-	-	-	X	X	-
33	Aug 13	man	200	-	-	X	SE	1	-	-	50 SE	400 E	-	-	-	-	-
												250 SE	-	-	X	X	5-10
34	Aug 20	man	100	-	X	-	NW	1	-	-	400 SE	-	Toward	Toward	Toward	-	20-30
35	Aug 23	man	600	X	-	-	NW	1	-	-	50 S	-	-	-	-	-	-
												500 S	-	-	X	X	5-10
				herds													
	Totals	2 Heli.	9250	7B	2B	18B		28	6	1			6B	1B	12B	17B	
		2 aircraft	(7650B)	1Mx	1Mx	1C							1Mx		4Mx	16%	
		32 man	(500C)			2Mx							7	1	15	4Mx	
			(1100Mx)	8	3	2							4B		4B	1C	
		Average	260										1Mx		1Mx	22/25	3(0-1)B
		Bull av.	270										Stood & ran				4(1-2)B
		Mud+C											for cover				4(3-5)B
		Average	230										2B		2B		4(5-10)B
													1C	toward			1(20-30)B
													1B	toward			2(3-5)Mx
																	1(5-10)Mx
																	1(20-30)Mx

REMARKS	Time of day
Helicopter hovered over fleeing herd/for kilometer. Sound & sight caused stampede of 2 km.	1600
Sound caused bulls to alert, and sight probably enhances flight, mildly startled.	1030
Bull stood and watched observer move away, then out of sight.	1035
Bulls distracted by noise from tower; head into wind toward and past tower.	0845
3 of 4 bulls close to observers run toward W bush, meeting 2 bulls farther W, all exit, bull near observer runs E along prairie.	1100
4 bulls from herd of 22 aware of observer by sight first, possibly scent, flee. 18 others watch for 5-10 min.	1130
Herd may have scented observer as well as sighting, very wary, being chased by wolves.	0800
Bulls spook and run at sound of observer, look back, and sight them run into bush.	2300
Cow distressed after losing calf to wolves; walks along ignoring, but aware of man, then turns and advances. Man retreats. Bison runs back to herd.	1030
(7) other bulls in same area remain down ignoring observer waking E past them to S.	1230
Herd mildly alarmed by camera sounds in tower.	0900
Bull flees from observer and rejoins 2 bulls then passes them. They are unaware of observer.	2120
A case where sound as well as sight contribute to reaction.	2115
Ran halfway toward E bush, then slowed up.	2106
Observer on roof up tower, very quiet yet bison spooked; scent? sight?	-
Observer beneath tower, metallic click causes bison to startle, sound?	-

REMARKS	Time of day
Herd contained one young calf whose mother led stampede to bush.	0715
Bulls did not respond to noise and scent of observer upwind in bush, but ran on sighting, not to nearest bush but away from them to bush.	2105
Bull trots 50 paces, back checks, then runs "4 foot jumps" 500 paces, stops.	0650
Bulls ran parallel to E bush, remain on prairie.	1400
Bulls retreat to bush nearby, resume direction of travel through bush.	1230
Bulls all rise, then slowly walk away after observer disppears in tower.	1355
Bulls stand at sounds of man in bush, run after sighting.	1100
Herd initially ran away from advancing men, then turned and ran NE for cover.	1500
3 bulls spook at sight of observer moving away, run for cover, cause 14 other bulls to watch.	2130
First (2) cows spot observer on Island 5, then 5 more, and lead group of 40 away and toward larger mixed herd.	1850
(15) cows and calves closest to tower reacted to sounds made by observer, walk N thru herd and chain reaction results; stampede away.	0600
2 other bulls only stand and watch observer with tails raised.	1340
- -	1350
Bulls startled by noise of observer in bush and of sight. Stampede.	1500
Only 1 of 4 bulls runs, other 3 stand and watch observer retreat.	1330
Observer interrupts bull about to drink. Bull walks away to NE.	1105

REMARKS	Time of day
Bull alarmed at sight of observer behind and moving returns and runs across path of observer.	1820
Bull threatens and follows observer until latter out of sight.	1120
Bull likely <u>smelled</u> and <u>heard</u> observer before seeing our movement.	1330

23% B	4% B	46% B	15% both A & C
			8% both S & A
			4% toward
	14% Mx	57% Mx	14% both A & C
			14% toward

Appendix 2. List of nursing sessions of bison calves recorded within 1 hour periods.

	Success		Length of session		Time of day (hours)															Who terminates			Remarks
	Attempt	Nurse	Min	Sec	0700 0800	0800 0900	0900 1000	1000 1100	1100 1200	1200 1300	1300 1400	1400 1500	1500 1600	1600 1700	1700 1800	1800 1900	1900 2000	2000 2100	2100 2200	Calf	Cow	Other	
May 17		X	2	40	X															?	?	?	
		X		5	X															X			
		X	1	35						X											X		
		X	5	50						X										X			
May 20		X	8	27		X														X			
	X																						
May 26		X		15														X					
May 27		X		25				X													X		Wolf watching
May 30		X	5+															X		X			Apx. length
June 2		X	6													X					X		
		X	1	40												X					X		
		X	?	?																?	?	?	No time
June 5		X	1	20					X											X			
		X		20						X										X			
June 6		X	5+										X							?	?	?	Apx. length
		X		70									X							?	?	?	
		X	4	35										X						?	?	?	
		X	?	?										X						?	?	?	
		X	?	?										X						?	?	?	No time
		X	?	?										X						?	?	?	
June 7		X	3	25																?	?	?	
June 13		X		20			X													X			
June 14		X	3	33								X								X			

Appendix 2. Continued.

Date	Success: Attempt	Success: Nurse	Length of session: Min	Length of session: Sec	Time of day (hours) 0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2100-2200	Who terminates: Calf	Who terminates: Cow	Who terminates: Other	Remarks
		X	10	57													X			X			
		X	5	50													X				X		
June 16		X	5+			X														X			
June 19		X	6+																	X			Apx. length
June 21	X								X											X			Apx. length
		X	50													X							No success
June 23	X											X									X		
		X	3	25								X											No success
		X	4	55										X						X			
		X		45										X							X		Bull interfered
	X													X							X		
		X	8	35												X				X			No success
		X	2	35													X						
June 25		X	5+																		X		
	X																	X			X		Apx. length
July 1	X																		X				No success
July 3		X	1	10												X							No success
	X													X									
July 13		X	4	40		X								X									No success
		X	4	35			X												X				
		X	4	40			X												X				

Appendix 3. Daily summary of calf observations.

Day Month	# calves in Pod per number. Different calves seen for each 15 minute period	# Diff. calves seen	Av. # calves in pod per # diff. calves seen	% Av. calves in pod # diff. calves seen	Total # pods	Total # singles	Total calf units
May							
13	0/2, 0/2	2		0%	0	2	4
17	3/4, 3/4, 3/4, 4/4, 4/4, 3/4	4	3.33/4	85%	6	0	24
18	4/4, 0/4	4	2/4	50%	1	1	8
19	4/4, 4/4, 4/4, 4/4, 4/4, 4/4, 4/4,	4	4/4	100%	7	0	28
20	4/4, 4/4, 4/4, 4/4, 0/4	4	3.2/4	80%	4	1	20
30	4/8, 4/8, 4/8, 4/8, 4/8, 4/8, 4/8, 4/8, 4/8, 4/8, 0/8, 0/8, 0/8, 0/8	8	2.86/4	35%	10	4	112
June							
1	2/8, 3/8, 2/8, 4/8, 2/8, 2/8, 2/8, 2/8, 3/8, 3/8, 3/8, 4/8, 2/8, 2/8, 4/8, 5/9,	8	2.63/8	33%	16	0	128
2	5/9	9	5/9	55%	2	0	18
5	3/6	6	3/6	50%	1	0	6
6	6/6, 6/6, 6/6, 6/6, 6/6, 6/6, 6/6, 6/6, 6/6	6	6/6	100%	9	0	54
7	6/6, 6/6	6	6/6	100%	2	0	12

Appendix 3. Continued.

Day Month	# calves in Pod per number. Different Calves seen for each 15 minute period	# Diff. calves seen	Av. # calves in pod per # diff. calves seen	% Av. calves in pod # diff. calves seen	Total # pods	Total # singles	Total calf units
June							
13	2/5, 5/5, 3/5, 4/5, 5/5, 5/5, 5/5, 5/5, 3/5, 3/5, 5/5, 2/5, 3/5, 0/5, 0/5, 0/5, 0/5, 0/5	5	2.78/5	55%	13	5	90
14	4/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 2/4, 2/4, 2/4, 2/4, 2/4, 2/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 4/4, 0/4	4	2/4	20%	8	17	100
15	0/3	3		0%	0	1	3
16	2/3, 2/3, 2/3, 2/3, 0/3, 0/3	3	1.33/3	44%	4	2	18
18	3/3, 3/3, 3/3, 3/3	3	3/3	100%	4	0	12
19	3/3, 3/3, 3/3, 3/3, 3/3, 0/3, 0/3, 0/3, 3/3, 3/3, 3/3, 3/3, 3/3, 3/3, 3/3, 3/3, 3/3, 9/3, 3/3, 3/3, 3/3,	3	2.59/3	85%	19	3	66
20	3/3, 3/3, 3/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 2/3, 2/3, 3/3	3	1.23/3	41%	6	7	39
21	0/3 x 33, ie. 8 hours, 3/3, 3/3, 0/3, 3/4, 3/4, 3/4, 3/4, 0/4, 0/4, 0/4	4		12%	6	33	130
22	3/4, 3/4, 3/4, 3/4, 3/4, 3/4, 3/4, 2/4, 0/4, 0/4, 0/4, 0/4, 4/4, 4/4, 2/4, 2/4, 2/4, 2/4, 3/4, 2/4, 4/4, 3/4	4	2.32/4	58%	18	4	88

Appendix 3. Continued.

Day Month	# calves in Pod per number. Different Calves seen for each 15 minute period	# Diff. calves seen	Av. # calves in pod / per # diff. calves seen	% Av. calves in pod / # diff. calves seen	Total # pods	Total # singles	Total calf units
June							
23	2/4, 2/4, 0/4, 0/4, 3/4, 3/4, 3/4, 3/4, 3/4, 2/4, 0/4, 0/4, 0/4, 0/4, 0/4, 0/4, 2/4, 3/4, 3/4	4	1.53/4	38%	11	8	76
		4	3.13/4	78%	8	0	32
25	2/4, 4/4, 4/4, 4/4, 4/4, 3/4, 2/4, 2/4						
27	0/4, 0/4, 0/4, 0/4, 4/4, 4/4, 2/4, 2/4, 4/4, 4/4, 4/4, 4/4, 4/4	4	2.46/4	62%	8	4	52
July							
1	0/3, 0/3, 0/3, 0/3, 0/3, 4/4, 4/4, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3, 0/3	7		8%	2	22	74
		4	.2/4	20%	1	4	20
2	4/4, 0/4, 0/4, 0/4, 0/4	3		0%	0	5	15
3	0/3, 0/3, 0/3, 0/3, 0/3						
13	0/4, 0/4, 4/4, 4/4, 3/4, 3/4, 0/4, 2/4	4	2/4	50%	7	4	44
	2/4, 0/4, 4/4	3	1.33/3	44%	3	3	18
22	0/3, 0/3, 2/3, 3/3, 3/3, 0/3						

Appendix 3. Continued.

Day Month	# calves in Pod per number. Different Calves seen for each 15 minute period	# Diff. calves seen	Av. # calves in pod per # diff. calves seen	% Av. calves in pod / # diff. calves seen	Total # pods	Total # singles	Total calf units
August							
20	0/7, 0/7, 0/7, 0/7, 0/7, 0/7, 0/7, 0/7, 2/7, 5/7	7	.7/7	10%	2	8	70
21	0/13 (x 16, ie. 4 hours) 4/13, 4/13, 4/13, 4/13, 6/13, 0/13, 0/13, 0/13, 0/13, 0/13, 13		.35/13	7%	5	20	338
22	0/8, 0/8, 0/8, 0/8, 3/8, 3/8, 3/8, 3/8, 3/8, 2/8, 2/8, 0/8, 0/8, 0/8, 0/8, 0/8, 0/8	8	1.12/8	14%	7	10	136